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### THE VALUE OF ZOOLOGY TO HUMANITY

THE task assigned me is to present to you as adequately as may be possible in the brief time allotted this topic, the significance of studies on animal parasites for the progress of the human race.

Since the earliest times of unwritten history human records bear evidence to the bitter warfare waged by men of all races against the large carnivores that threatened their existence and played havoc with the useful animals they had brought under control. As time went on and his purview gained in breadth man turned his attention to noxious types such as the snakes, and to smaller forms like the rats that are real though less conspicuous foes. And, finally, in very recent years, he has learned to understand that minute organisms like the blood-sucking insects are not only sources of discomfort but also play an essential part in the transmission of many of the microscopic organisms that produce disease. He knows that these organisms both plague and destroy the domesticated animals, that they greatly reduce his own efficiency and, threatening his very existence, drive him away from rich and fertile territory or in a single epidemic wipe out families, villages, or even whole nations. In short, animals nowhere affect man more extensively and more seriously than in those relations in which they appear as the agents in producing or transmitting disease, and it is of fundamental importance for the progress, prosperity and even existence of the human race that those relations should be investigated, determined with precision, and brought under control.

This in a broad general way is the problem of parasitology, and it is important at the very outset to indicate that it is not set off from other studies on animal life by any hard and fast limits. The structure of

parasitic animals can be interpreted rightly only by the results of knowledge gained concerning the anatomy of free-living forms; the development of parasitic species depends for its explanation on the results of studies on the development of animals generally; the habits of parasite and host are so intimately interlocked that the key to the life history of a parasite is found in the associations of the host. Now the recognition of this intimate and necessary connection between zoology in the narrower sense and parasitology is of relatively recent date and has favored promptly and conspicuously the contributions of zoology to human welfare. Brief reference to the history of science may serve to make this point somewhat clearer than it appears in the general statement.

As a matter of fact parasitology is of the oldest phases of the study of animal life and its even yet faintly recognized relations to man. Diseases caused by animal parasites played evidently an important part in the economy of the nations of antiquity. The oldest medical works that have come down to us give intelligible records of the presence in man of such guests and in some cases recognizable descriptions of the parasites themselves. This study pursued under the direction of the priests and medical men was developed apart from other fields of zoology. As a result the knowledge thus gained reached more considerable proportions and was more widely disseminated at an early date than the general knowledge of animal structure or of animal function. To some extent the separateness of the two fields exists at the present date, to the disadvantage of scientific progress and human welfare.

The parasites known to the ancients were of course the larger, more conspicuous forms. And while some important facts were included, their knowledge was con-

fused with such a mass of fable and superstition that its value as a guide to a rational life was not large. Moreover these large forms are not the most dangerous parasites, *i. e.*, those of greatest significance for human existence; and hence in that period the contributions from the study of parasitology to human welfare were not conspicuous.

Something like a century ago students came to see, faintly and slowly at first, that animals affect man very directly because some of them are definite factors in the production or transmission of disease. One can hardly overestimate the importance of the contributions made by zoologists toward the solution of the problems presented in this field. At first the instances of animals as causes of disease appeared rare, and were recognized only among the higher parasites. In particular cases of this type a demonstration was achieved and the evidence became clear as scattered observations of individual workers were brought together by some master mind and formed into a consistent and sufficient explanation of the malady. A splendid illustration is furnished by the epoch-making investigations of Leuckart and others on trichina. Owen had found in a dissecting room in London a worm encysted in human muscle and had rightly interpreted it as a nematode; another form was discovered by Leidy in Philadelphia in pig muscle and recognized as identical with that reported by Owen; and, finally, adult intestinal parasites were obtained from cases in Germany which had been previously diagnosed as typhoid, and all these were shown to represent only different stages in the life history of a single parasite, the trichina. The natural result of these studies was the formulation of a rational prophylaxis which, when adopted, eliminates trichinosis absolutely from the list of human ailments.

These early and significant discoveries were accompanied by others of lesser importance on various other worms but remained after all relatively isolated for a long time. The reason is not hard to find. The rapid and brilliant rise of bacteriology to a position of prominence and its overwhelming demonstrations that bacteria were the causes of many diseases led investigators to seek insistently for them in all maladies of an apparently infectious type. Failure to find them was explained on the basis of defective technic and the possible existence of other disease-producing organisms was generally overlooked.

To be sure, malaria had been traced to a protozoon, but the instance remained isolated for many years until a combination of causes directed scientific attention to the importance of more exact studies on that and allied organisms, and these in turn opened up a new field, that of protozoal diseases. In the investigation of this field, zoological students have performed the chief and almost the only extensive work, and the results of their researches have been of tremendous significance to human progress.

In his "Malaria Studies of a Zoologist" Grassi laid the foundations for the complete elucidation of the life history of the *Plasmodium malarie* and with that the basis for the adoption of communal and individual habits which have freed the world from the menace of a disease that has exacted a heavy toll from the great nations of all ages in human history. Coupled with this the demonstration of the rôle of the mosquito in transmitting yellow fever made possible for instance the building of the Panama Canal and the maintenance of a highly developed and cultured community on the Isthmus, whence less than half a century before the French workers had been driven out by pestilences so frightful

that no system of recruiting the workers could keep pace with the destruction of human life wrought among them by these diseases.

One should not pass without notice a group of protozoal and bacterial diseases transmitted by insects, such as sleeping sickness, bubonic plague and the various relapsing fevers, all of which owe their spread in nature exclusively to inoculation by bedbugs, ticks and biting flies. The significance of scientific discoveries which have led to formulation of measures for the control of such diseases may be estimated in correct propositions when one bears in mind that at a very recent date malaria has claimed in Italy alone 200,000 victims annually, sleeping sickness 500,000 in Africa and plague in India has often destroyed more than a million victims in the course of six months. Among those who have contributed prominently to the study of these organisms and to the solution of the problems of the diseases they produce must be named the zoologists Minchin and Fantham; of the work done on the insects that transmit such organisms appropriate mention is made by another speaker in this symposium.

Not less significant is the story of the hookworm and its ravages, which have extended over every part of the globe in tropical and subtropical regions and have justified the organization of a great philanthropic movement to combat them. The first great step in advance in the handling of this problem was taken when at the International Zoological Congress in Berne, Switzerland, the zoologist Looss demonstrated before a critical and unbelieving audience the intricate story of the migrations of this parasite and its mode of gaining entrance to the human host. Previous to that time, no effective measures for combating the disease had been worked out, save the procedure of abandoning infected

territory which was in itself a clear confession of inability to cope with the difficulty. As a direct result of the definite knowledge concerning the life history of the parasite and its point of attack upon the human system, a code of procedure has been worked out so definitely that its introduction is in fact resulting in the elimination of the disease from human consideration. Foremost among those who have aided in achieving the brilliant results of the campaign against the hookworm stands the name of the zoologist Stiles.

When the city of Manila came under the control of the United States of America, one in four, if not one in three, of all the deaths occurring in its limits were due to the attack of the parasite of amebic dysentery. While it is premature to say that this problem has been solved, still, studies on the structure and life history of this and similar forms by the zoologist Schaudinn and others have contributed such information concerning the life history and the effects of this parasite as to indicate successful lines of defense against its attacks and to reduce greatly the toll of human life it exacts.

But these items do not indicate the extension of knowledge regarding such organisms. Even among the higher parasites studies of recent date have added to the list of forms that menace man several intestinal flukes, three blood flukes, a number of tapeworms and various roundworms, and there is no reason to think the list is complete. Each form demands an individual study of its structure, life history and habits before definite measures can be formulated for protection against its attacks. To recount all that has been done in the many cases would transcend the possible limits of this paper. A very large part of the significant information regarding these forms has been furnished by zoologists. When, however, protozoan parasites are taken into consid-

eration the field is vastly extended. Both in numbers and variety and probably also in virulence of attack they surpass the metazoan parasites. The volume of the literature dealing with such organisms has increased with great rapidity and new organisms as well as new problems are being discovered every day. When one adds to all this the important problems that concern parasites affecting domestic animals and thus the material welfare of the human race, the extent of the field of work on animal parasites can be to some extent appreciated. The mere listing of the names of those who have worked in this field fills pages in every annual bibliography of zoology.

Such examples as have been cited could be multiplied many fold. Some of the parasites are acknowledged to be serious foes of human progress and if in other cases the effects are less conspicuous because the organisms are confined within narrow geographical limits, still the significance of their control is no less important to the human race. Furthermore, with the development of commerce and the increasing movement of individuals from place to place, disease has lost its earlier local limitation and has become an international menace. To all students of social evolution disease looms high as a controlling factor in human affairs. History furnishes many records of epidemics that have depopulated great areas, routed victorious armies, and reduced virile and fruitful civilizations to an inefficient and sordid level. Throughout the expanse of the tropics, where nature rewards the efforts of the cultivator of the ground in a degree beyond all comparison with the results obtained in temperate climates, human social organization has generally remained on a low plane, or if at any point it took a brief spurt, the end of the

advance came quickly and the nation sank to the common level again.

Man's failure thus far to achieve the conquest of the tropics may be traced distinctly to the ravages of tropical diseases untrained by natural limitations that are found in other climatic environments. Now these diseases are primarily those produced by animal parasites and in the control of such diseases lies consequently the possibility of utilizing the natural resources of the globe at the point of their greatest richness. What greater service could be rendered to humanity than the continued maintenance of highly organized social communities in the richest regions on the surface of the earth? The result already achieved in the Panama Canal zone and at many other individual points in the tropics can be duplicated generally. When this is done the possibilities of human existence will have been enormously enriched. Certainly the demonstration of such a possibility which has already been given in work quoted above should rank as the greatest achievement of zoological studies and inferior only to the realization of that possibility when the conquest of the tropics is completed because of the mastery of its diseases.

Before closing the discussion, I should like to call your attention to another phase which is much less conspicuous than those which have been treated before, but which in my opinion has distinct importance. This is the stimulus given by parasitology to the scientific discussions of biology and consequently to the extension of knowledge and to the general advantage accruing therefrom. Important side lights have been thrown upon morphology by study of the processes of modification and degeneration which are so conspicuously exemplified by parasitic forms. The life history and relationship of these types show many features

unique in themselves which serve to illuminate general biological principles. One can not for a moment doubt that in some way or other the processes of existence have worked striking modifications in the parasitic forms when one compares them with their free-living relatives and scans the changes which take place in the individual development. Not even the most extreme conservative would wish to maintain that the parasite was an original product, or would hesitate to grant that it had become adapted to its present mode of life. Yet more extraordinary and far-reaching structural modifications could hardly be asked for or found than those which are evident in the parasitic organisms. Nor would it be easy to conceive more intricate or more precisely balanced relations than those which exist between some parasites and their hosts. The development, modifications and habits of the parasite have been coordinated with the conditions of existence in the host in strikingly precise fashion. Investigation has as yet only begun to work out the adjustments which have arisen independently and in great variety in different species and groups of parasitic species. The field is one that offers unusual opportunities at the present time to the investigator.

We do not know how far an intimate study of these problems may carry us towards the explanation of the process of evolution in free-living organisms. There is reason to think that the change has been more rapid as well as more radical among parasitic species. And if so, the study of this problem at this point may be expected to throw welcome light on the factors that lead to structural changes in living organisms. Any such study will certainly serve an important purpose in broadening the human mind and encouraging it to seek the

solution of the problems of existence more vigorously than it has even done as yet.

The outlook for the future constitutes no less than the achievements of the past, a real contribution to the cause of human progress.

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#### THE INDIGEN AND CULTIGEN

If an author were to prepare a flora or manual of cultivated plants in any country, he would come hard against the fact that he deals with two gentes or types of species.

One gens has recorded origin, with the typical form well recognized and probably represented by a "type specimen" in the herbarium of the person who "founded" the species. It is an indigen of known habitat.

The other gens is a domesticated group of which the origin may be unknown or indefinite, which has such characters as to separate it from known indigens, and which is probably not represented by any type specimen or exact description, having therefore no clear taxonomic beginning. I trust I may be pardoned for calling such species or group a cultigen.

A good example of the cultivated indigen is *Thuja occidentalis*. Although there are many horticultural forms, their relationship is understood, we are familiar with the species in the wild, and we have the whole case before us. The variations under domestication are indeed great, but we readily range them with what we call the species itself.

A good example of the cultigen is *Zea Mays*. We know neither its country nor its origin. It is widely variable. If a botanist had before him good material of all these variations, I do not know what one of them he would take as "the type." It is a composite gens, with no clear taxonomic center from which variations diverge.

Here we have two classes of facts, with no adequate way of expressing one of them in taxonomy.

If *Zea Mays* were an isolated case we could treat it as an exception. I have before me a list of one or two hundred comparable cases,